

C L A I M S

1. A method for determining the absolute position under water of a submersible vessel having a dead reckoning navigation system not receiving position information from outside the vessel, where the vessel receives acoustic signals from a reference station having a known absolute position and calculates its range from the reference station, wherein said acoustic signals are received from the same reference station in several arbitrary positions of the vessel, and that estimated absolute positions of the vessel are calculated using sets of data, each set of data comprising said calculated range and navigation data from the dead reckoning navigation system, said navigation data being valid concurrently with said calculated range.

2. A method according to claim 1, wherein data from each received signal are processed immediately or shortly after reception, providing for a substantially continuous estimation of absolute position.

20 3. A method according to claim 1, wherein the position of the reference station in a relative coordinate frame of said dead reckoning navigation system is estimated.

4. A method according to claim 1, wherein the estimated absolute position data are used for updating the dead reckoning system's relative position data.

5. A method according to claim 1, wherein estimates are made of parameters intrinsic to the nature of the dead reckoning navigation system, such as sea currents, and relative position data from the dead reckoning navigation system 30 are compensated by the estimate of said parameters.

6. A method according to claim 5, wherein a least-squares algorithm is used to estimate absolute position and parameters intrinsic to the nature of the dead reckoning navigation system.

35 7. A method according to claim 5, wherein a Kalman filter is used to estimate absolute position and parameters intrinsic to the nature of the dead reckoning navigation system.

8. A method according to claim 1, wherein said estimates are made further utilizing information on the depth of the reference station.

9. A method according to claim 1, wherein the reference station is placed at a fixed absolute position.

10. A method according to claim 9, wherein the absolute position of the reference station is determined by the submersible vessel at the surface of the water collecting absolute position data in a number of positions from a positioning system usable at the surface of the water, and while surfaced receiving acoustic signals from the reference station, and calculating range data from said signals, position and range data preferably being processed on board the vessel.

15 11. A method according to claim 1, wherein the reference station is launched from the submersible vessel.

12. A method according to claim 1, wherein the reference station is collected by the submersible vessel after estimating an absolute position.

20 13. A method according to claim 1, wherein the reference station comprises an acoustic transponder.

14. A method according to claim 1, wherein the reference station comprises an acoustic beacon.

25 15. A method according to claim 1, wherein the reference station is placed on the surface of the water, preferably in a buoy or a vessel.

30 16. A method according to claim 15, wherein the reference station receives absolute position data from a positioning system usable at the surface of the water, and relays such data to the submersible vessel.

35 17. A method according to claim 15, wherein the reference station exchanges communication data with a communication system usable at the surface of the water, and preferably as well exchanges such data with the submersible vessel.

18. A method according to claim 15, wherein the reference station is placed in a submersible vessel being surfaced during use of the reference station.

19. A method for determining the absolute position under water of a submersible vessel having a dead reckoning navigation system not receiving position information from outside the vessel, wherein the vessel receives acoustic signals from a reference station having a known absolute position and calculates its range from the reference station, wherein said acoustic signals are received from one reference station in one or more positions of the vessel; wherein data for rate of change of the vessel's range from the reference station ("range rate data") are derived from said acoustic signals; and wherein estimated absolute positions of the vessel are calculated using said calculated range, said range rate data, and navigation data from the dead reckoning navigation system.

15 20. A method according to claim 19, wherein said range rate data are derived from recordings of Doppler shifts in frequencies of said acoustic signals.

21. A method according to claim 19, wherein said range rate data are derived from recordings of time discrepancies in the arrival times of spread spectrum pulses embedded within said acoustic signals.

22. A method according to claim 19, wherein data from each received signal are processed immediately or shortly after reception, providing for a substantially continuous estimation of absolute position.

23. A method according to claim 19, wherein the position of the reference station in a relative coordinate frame of said dead reckoning navigation system is estimated.

24. A method according to claim 19, wherein the estimated absolute position data are used for updating the dead reckoning system's relative position data.

25. A method according to claim 19, wherein estimates are made of parameters intrinsic to the nature of the dead reckoning navigation system, such as sea currents, and relative position data from the dead reckoning navigation system are compensated by the estimate of said parameters.

26. A method according to claim 25, wherein a least-squares algorithm is used to estimate absolute posi-

tion and parameters intrinsic to the nature of the dead reckoning navigation system.

28. A method according to claim 25, wherein a Kalman filter is used to estimate absolute position and parameters 5 intrinsic to the nature of the dead reckoning navigation system.

29. A method according to claim 19, wherein said estimates are made further utilizing information on the depth of the reference station.

10 30. A method according to claim 19, wherein the reference station is placed at a fixed absolute position.

31. A method according to claim 30, wherein the absolute position of the reference station is determined by the submersible vessel at the surface of the water collecting 15 absolute position data in a number of positions from a positioning system usable at the surface of the water, and while surfaced receiving acoustic signals from the reference station, and calculating range data from said signals, position and range data preferably being processed on board the 20 vessel.

32. A method according to claim 19, wherein the reference station is launched from the submersible vessel.

33. A method according to claim 19, wherein the reference station is collected by the submersible vessel after 25 estimating an absolute position.

34. A method according to claim 19, wherein the reference station comprises an acoustic transponder.

35. A method according to claim 19, wherein the reference station comprises an acoustic beacon.

30 36. A method according to claim 19, wherein the reference station is placed on the surface of the water, preferably in a buoy or a vessel.

37. A method according to claim 36, wherein the reference station receives absolute position data from a 35 positioning system usable at the surface of the water, and relays such data to the submersible vessel.

38. A method according to claim 36, wherein the reference station exchanges communication data with a commu-

nication system usable at the surface of the water, and preferably as well exchanges such data with the submersible vessel.

39. A method according to any of claim 36, wherein 5 the reference station is placed in a submersible vessel being surfaced during use of the reference station.

40. A method for scanning an underwater survey area by means of a submersible vessel traveling a desired path, the vessel having a dead reckoning navigation system not 10 receiving position information from outside the vessel, where the vessel receives acoustic signals from a reference station having a known absolute position and calculates its range from the reference station, wherein the absolute position of the vessel is intermittently being determined.

15 41. A method according to claim 40, wherein said area extends beyond the operational reach of said reference station, and the intended trajectory of the vessel is arranged to bring the vessel within said operational reach at regular intervals of time.

20 42. A method according to claim 40, wherein the intended trajectory of the vessel is arranged to bring the vessel within a minimum distance of every point in said area.

43. A method according to claim 12, wherein said 25 reference station is placed at a fixed absolute position.

44. A method according to claim 40, wherein the absolute position of said reference station is determined by said submersible vessel at the surface of the water collecting absolute position data in a number of positions from a 30 positioning system usable at the surface of the water, and while surfaced receiving acoustic signals from said reference station, and calculating range data from said signals, position and range data preferably being processed on board said vessel.

35 45. A method according to claim 40, wherein said reference station is launched from said submersible vessel.

46. A method according to claim 40, wherein said reference station is collected by said submersible vessel after estimating an absolute position.

47. A method according to claim 40, wherein said reference station comprises an acoustic transponder.

48. A method according to claim 40, wherein said reference station comprises an acoustic beacon.

49. A method according to claim 40, wherein said reference station is placed on the surface of the water, preferably in a buoy or a vessel.

50. A method according to claim 49, wherein said reference station receives absolute position data from a positioning system usable at the surface of the water, and relays such data to said submersible vessel.

51. A method according to claim 49, wherein said reference station exchanges communication data with a communication system usable at the surface of the water, and preferably as well exchanges such data with said submersible vessel.

52. A method according to claim 49, wherein said reference station is placed in a submersible vessel being surfaced during use of the reference station.

53. A system for determining the absolute position under water of a submersible vessel by means of the method in claim 1, the system comprising:

- a reference station having acoustic communication means;
- acoustic communication means on board the vessel;
- a dead reckoning navigation system on board the vessel;

wherein the system comprises computing means, preferably on board the vessel, adapted to estimating absolute position data from consecutive receptions of signals from one and the same reference station, together with relative position data from the dead reckoning navigation system.

54. A system according to claim 53, wherein the dead reckoning system comprises an Inertial Navigation System.

55. A system according to claim 53, wherein the dead reckoning system comprises:

- 5 - a number of gyros;
 - a number of accelerometers;
 - a Doppler Ground Velocity Log;
 - a direct or indirect speed of sound measurement sensor; and
- 10 - a pressure sensor.

56. A system according to claim 53, wherein the submersible vessel is adapted to carry a number of reference stations and to launch the stations independently.

57. A system according to claim 53, wherein the submersible vessel is adapted to collect a number of reference stations.

58. A system according to claim 53, wherein the reference stations are acoustic transponders or beacons, resting on the sea floor or suspended above an anchor resting at the sea floor.

59. A system according to claim 53, wherein the reference stations are located on buoys or vessels floating at the surface of the water.

60. A system for determining the absolute position under water of a submersible vessel by means of the method in claim 19, the system comprising:

- a reference station having acoustic communication means;
 - acoustic communication means on board the vessel;
- 30 - a dead reckoning navigation system on board the vessel;

wherein the system further comprises computing means, preferably on board the vessel, adapted to estimating absolute position data from one or more receptions of signals from one and the same reference station, together with relative position data from the dead reckoning navigation system.

61. A system according to claim 60, wherein the dead reckoning system comprises an Inertial Navigation System.

62. A system according to the claim 60, wherein the dead reckoning system comprises:

- 5 - a number of gyros;
 - a number of accelerometers;
 - a Doppler Ground Velocity Log;
 - a direct or indirect speed of sound measurement sensor; and
- 10 - a pressure sensor.

63. A system according to claim 60, wherein the submersible vessel is adapted to carry a number of reference stations and to launch the stations independently.

64. A system according to claim 60, wherein the submersible vessel is adapted to collect a number of reference stations.

65. A system according to claim 60, wherein the reference stations are acoustic transponders or beacons, resting on the sea floor or suspended above an anchor resting at the sea floor.

66. A system according to claim 60, wherein the reference stations are located on buoys or vessels floating at the surface of the water.